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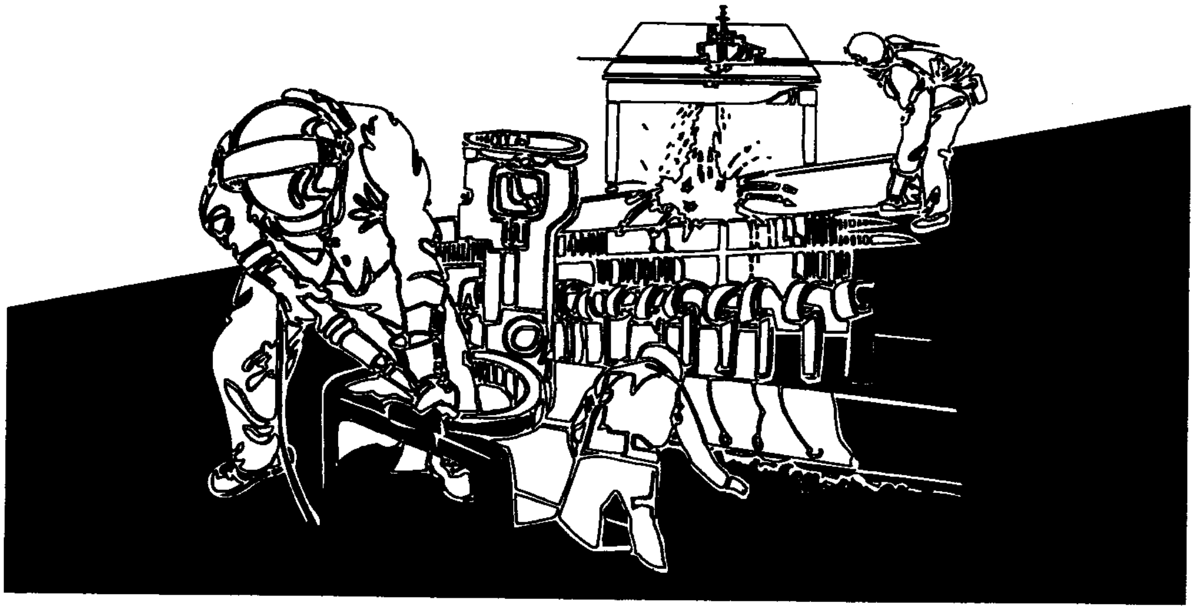
CENTERS FOR DISEASE CONTROL AND PREVENTION

NIOSH HEALTH HAZARD EVALUATION REPORT

HETA 93-0771-2437
ALASKAN AIDS ASSISTANCE ASSOCIATION
ANCHORAGE, ALASKA



U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
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PREFACE

The Hazard Evaluations and Technical Assistance Branch of NIOSH conducts field investigations of possible health hazards in the workplace. These investigations are conducted under the authority of Section 20(a)(6) of the Occupational Safety and Health Act of 1970, 29 U.S.C. 669(a)(6) which authorizes the Secretary of Health and Human Services, following a written request from any employer and authorized representative of employees, to determine whether any substance normally found in the place of employment has potentially toxic effects in such concentrations as used or found.

The Hazard Evaluations and Technical Assistance Branch also provides, upon request, medical, nursing, and industrial hygiene technical and consultative assistance (TA) to federal, State, and local agencies; labor; industry; and other groups or individuals to control occupational health hazards and to prevent related trauma and disease.

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SUMMARY

On March 18, 1993, the National Institute for Occupational Safety and Health (NIOSH) received a management request to conduct a health hazard evaluation (HHE) for the Alaskan AIDS Assistance Association (AAAA). The AAAA is presently renovating two duplexes which will provide housing for homeless HIV-infected persons. Since this group is at high risk for developing tuberculosis (TB), NIOSH was asked to evaluate the potential for *Mycobacterium tuberculosis* (Mtb) transmission in the residential facility. In response to this request, NIOSH investigators conducted an environmental evaluation on April 13, 1993.

At the time of the site visit, a walk-through survey of one of the duplexes was conducted. Additionally, the architectural drawings and patient acceptance criteria were reviewed. Prior to the NIOSH site visit, the blueprints of the facility were reviewed to select a room which could be designed for limited access. This room would be used to separate a suspected infectious individual from the other residents of the facility in limited cases when immediate transport to an appropriate health care facility is not possible. Based on a review of the plans and a walk-through of the facility, a room was recommended based on its remote location within the complex and the ability to optimize ventilation rates. According to the current architectural drawings, the exhaust fans located in the bathrooms will be the only mechanical ventilation provided in the facility; replacement air will not be mechanically provided. The exhaust fans will only be used intermittently and are controlled by a power switch in the bathroom.

In order to optimize ventilation rates in the selected room, the architect proposed a system which consists of a heat exchanger and a bathroom exhaust. Utilizing this system, approximately nine air changes per hour (ACH) can theoretically be achieved. Further evaluation will be necessary to ensure that short-circuiting of the supply and exhaust air flows does not occur. Additional filtration of room air may be provided by a portable, high-efficiency particulate air (HEPA) unit.

The facility has established a written protocol for the acceptance of clients to the facility. All clients will be screened for Mtb infection and TB before they are admitted to the facility. Any client who develops TB while residing at the facility will be immediately transferred to an appropriate treatment center until no longer infectious. Presently, the facility does not have a written TB control program that includes the early identification of infected employees, including volunteers, as required by the Occupational Safety and Health Administration (OSHA) for health

care settings, correctional institutions, homeless shelters, and long-term care facilities for the elderly.

A personal respiratory protection program had not been implemented for the employees and volunteers potentially at risk. The majority of the health-care providers who will participate in this program reportedly wear surgical masks while in the presence of an individual with suspected or confirmed TB. Surgical masks do not offer appropriate protection from Mtb, because of (a) the poor face seal of the mask to the wearer's face, and (b) the potential leakage of respirable particles through the filter media. Currently, NIOSH, CDC, and OSHA recommend the use of a NIOSH-approved disposable high-efficiency particulate air (HEPA) half-mask respirator as a minimum level of protection from the transmission of Mtb.

A potential health hazard exists for workers who will be exposed to individuals with infectious TB in the facility, due to deficiencies in the ventilation system and the lack of appropriate respiratory protection. Presently, there are no guidelines addressing Mtb exposures in residential facilities for HIV-infected individuals, however, many of the guidelines pertaining to health care facilities are applicable for this type of high-risk setting. This report contains recommendations regarding administrative and engineering controls, as well as the use of appropriate respiratory protection, which will assist in the reduction of Mtb transmission in the facility, as well as during the transport of potentially infectious individuals.

Keywords: SIC 8361 (Social Services, Residential Care), tuberculosis, TB, *Mycobacterium tuberculosis*, HIV-infection and TB, skin testing, ventilation.

INTRODUCTION

In March 1993, the National Institute for Occupational Safety and Health (NIOSH) received a management request to conduct a health hazard evaluation (HHE) for the Alaskan AIDS Assistance Association (AAAA) in Anchorage, Alaska. The AAAA is renovating two duplexes which will provide housing for homeless HIV-infected persons, a group at high risk for *Mycobacterium tuberculosis* (Mtb) infection and tuberculosis (TB). Because of concerns regarding the potential for Mtb transmission in the residential facility, NIOSH was asked to evaluate the facility and make recommendations regarding TB infection control during the renovation period. In response to this request, NIOSH investigators conducted an environmental evaluation of the residential facility on April 13, 1993.

FACILITY DESCRIPTION

The Alaskan AIDS Assistance Association, a nonprofit organization, provides support and education to Alaskans infected with the human immunodeficiency virus (HIV). Once the duplexes are completed, the facility will provide long-term supportive housing for eight HIV-infected individuals and short-term assisted living for five HIV-infected individuals. Although the main purpose of the facility is to provide housing, the long-term residents will also receive comprehensive medical services such as hospice support, home health care, medical referrals, and mental health counseling. The short-term residents will be comprised of rural Alaskans receiving housing for up to 60 days while receiving medical treatment in Anchorage. The program is expected to serve 25 people with HIV infection or acquired immuno-deficiency syndrome (AIDS) each year. Clients will be referred to the residential facility from homeless shelters, drug treatment centers, health clinics, and correctional facilities, all of which have reported high rates of Mtb-infected individuals. This housing program will involve close interaction among clients and staff. There will be two on-site facility managers: a site manager and a housing coordinator. The site manager will live at the facility. Additionally, an unknown number of volunteers and case managers, including health care workers, will provide assistance on-site.

The duplexes are located on separate, adjacent lots and are being remodeled to form four similarly designed units (units A, B, C, and D) with two units per duplex (see Figure 1 for the facility layout of units A and B). Unit C will be the on-site manager's living quarters. All residents will have private bedrooms, and will share common bathrooms and kitchens. There is no central heating, ventilating, and air-conditioning (HVAC) system for the facility which would supply conditioned, outside air. Heat will be provided through baseboard heating and air will be exhausted through the bathrooms (only when the fan is turned on by the residents).

TUBERCULOSIS AND HIV

Tuberculosis is an infectious disease caused by the bacterium *Mycobacterium tuberculosis* (Mtb). In 1992, there were 26,673 reported tuberculosis cases (10.5 cases per 100,000 people) in the United States, an increase of 1.5% over the previous year. Alaska reported 57 tuberculosis cases in 1992 (9.7 cases per 100,000 people).[1] Populations known to be at a high risk for infection are medically underserved populations (including ethnic minority groups such as Alaskan Natives and Hispanics), foreign-born persons from high prevalence countries, current or past prison inmates, the homeless, alcoholics, intravenous drug users, the elderly, residents of long-term care facilities, and persons with HIV infection.[2,3,4]

Mtb is carried on airborne droplet nuclei that are expelled into the air by individuals with untreated pulmonary or laryngeal tuberculosis. Due to the small size of the droplet nuclei (1-5 micrometers), normal air currents can keep them airborne for long periods of time and, consequently, spread them throughout a room or building. Infection occurs when a person inhales Mtb and the bacilli become established in the alveoli of the lungs, where they multiply and spread throughout the body. The predominant symptom associated with tuberculosis is a chronic cough, usually with the production of sputum; fever, weight loss, and fatigue are also common.

A majority of persons who become infected are asymptomatic and do not go on to develop active, infectious TB. However, the tubercle bacilli often survive the host defense mechanisms and remain in the host as dormant but viable. Approximately 10% of the healthy, infected individuals will develop illness after an interval of months, years, or decades, when the bacteria begin to replicate and produce disease due to a weakened immune system.[5] It is estimated that the number of persons in the United States with latent Mtb infection is between 10 million to 15 million.[4]

Individuals who are infected with the HIV are particularly at risk for developing TB both from reactivation of latent Mtb infection and from newly acquired exposure to Mtb.[6] Not only are these individuals more susceptible to the disease, but they are often times grouped together either in residential facilities or on hospital wards which may contribute to the high rate of disease transmission among this population.[7,8,9] Recently, an outbreak of TB in a residential facility for HIV-infected persons in San Francisco resulted in a minimum overall rate of Mtb infection among exposed HIV-infected patients of 50%, with one individual progressing to active TB within four weeks. Two of the patients died of TB. Additionally, among the 28 staff members, six had tuberculin skin test conversions as a result of the exposure.[10] In another outbreak, a 22% skin-test conversion rate was attributed to transmission of multi-drug-resistant Mtb from an HIV-positive client in a residential substance-abuse treatment facility.[11] In another hospital outbreak, where 18 HIV-infected patients were found to be exposed to Mtb, active TB developed in eight of the patients. Seven of these patients developed active TB within 60 days of diagnosis of the index case. Additionally, a nurse developed active TB, and four volunteers had documented skin test conversions, all of which were attributed to the index case.[12] These studies strongly indicate that health-care and other facilities should be particularly alert to the need for preventing Mtb transmission in settings in which persons with HIV infection reside, receive care, or work.

EXPOSURE TO *MYCOBACTERIUM TUBERCULOSIS*

For many chemical and physical agents, there exist recommended workplace exposure limits based on epidemiologic research or toxicologic data from animal and human studies. These limits are intended to provide a safe working environment. For droplet nuclei containing Mtb, however, no safe exposure level has been identified. That is, any concentration of droplet nuclei is assumed to present some risk of infection.[13,14,15]

The control of tuberculosis requires a hierarchy of different measures including: (1) administrative controls; (2) engineering controls; and (3) respiratory protection. Administrative measures are the first and most important approach in reducing the risk of exposure to persons with infectious tuberculosis. This includes the early identification, treatment, and isolation of infected patients, and the use of effective work practices. Engineering controls can be used to further prevent the spread of Mtb and reduce the concentration of infectious droplet nuclei in air. These controls include the use of local exhaust ventilation to control droplet nuclei at their source; general ventilation to dilute and remove contaminated air; proper air flow direction to prevent the contamination of adjacent areas; and air cleaning mechanisms, such as high efficiency particulate air (HEPA) filtration. Respiratory protection should be used by persons entering rooms where individuals with known or suspected infectious TB are being isolated; during cough-inducing or aerosol-generating procedures on patients with known or suspected TB; and in other areas where administrative and engineering controls are not likely to protect persons from inhaling infectious airborne droplet nuclei, such as during the transportation of an infectious individual.

Utilizing a combination of these methods should reduce exposures to Mtb, however, there are no evaluation methods currently available to quantify the level of reduction provided.

GENERAL EVALUATION CRITERIA AND GUIDELINES

In October 1993, CDC published a draft document entitled, *Guidelines for Preventing the Transmission of Tuberculosis in Health Care Facilities, Second Edition*, for public comment.[5] This document was developed to replace the previously published CDC guidelines for the prevention of TB in health-care facilities, and discusses the importance of administrative and engineering controls, respiratory protection, early identification and screening, risk assessment, and the need for a written TB control plan, skin testing program, and worker education.[21] Although these are recommended guidelines for health care facilities, correctional institutes, homeless shelters, drug rehabilitation centers, and long-term care facilities for the elderly, many of the recommendations are applicable to other settings.

In October 1993, the Occupational Safety and Health Administration (OSHA) issued an enforcement policy for inspections, based on the CDC draft guidelines.[16] Several items which OSHA is requiring are: 1) a protocol for the early identification of individuals with active TB; 2) medical surveillance for employees using skin tests; 3) evaluation and management of workers with positive skin tests, skin test conversions, or symptoms of TB; 4) placement of individuals with confirmed or suspected TB in isolation rooms and performing high risk procedures in areas with negative pressure and appropriate exhausts; and 5) training and information for employees concerning issues such as Mtb transmission, signs and symptoms of the disease, medical surveillance, follow-up therapy, and proper use of controls (i.e., respiratory protection).

Section 5(a)(1), the "general duty clause" of the Occupational Safety and Health Act of 1970, is the legal basis of federal OSHA's TB enforcement policy. Under this clause, employers must provide a workplace free from hazards that could seriously harm or kill employees. Several other specific standards are also applicable to OSHA's TB protection program such as the Respiratory Protection Standard (29 CFR 1910.134), Accident Prevention Signs and Tags (29 CFR 1910.145), Access to Employee Exposure and Medical Records (29 CFR 1910.20), and Log and Summary of Occupational Injuries and Illnesses (29 CFR 1904).

ADMINISTRATIVE CONTROLS

Early Identification and Screening

To minimize the transmission of Mtb, early identification and treatment of infected persons, both with and without active disease are necessary. Routine screening of health care workers, at least annually, is recommended by CDC; workers who routinely perform procedures with a high risk of exposure to Mtb (e.g., bronchoscopy, sputum induction, or aerosol treatments given to patients who may have tuberculosis) should be retested at least every six months.[5] Screening for the identification of individuals with tuberculosis infection is commonly accomplished using the tuberculin skin test. For the tuberculin skin test, a small amount of purified protein from Mtb is injected into the upper layers of the skin. If the tested person has previously been infected with Mtb, his or her immune system usually reacts against this protein; the reaction causes a reddish swelling at the site of the injection (a positive result). If the person has not been infected previously, there will be little or no reaction (a negative result). There are standardized guidelines for interpreting the test.[17]

In addition to identifying individuals for whom prophylactic treatment is appropriate, routine screening can also serve as a surveillance tool to identify areas or occupations for which there may be an increased risk of Mtb transmission. If a person with a previously negative skin test converts to positive, the test should be followed by a chest X-ray to determine whether active TB has developed. Drug therapy, to prevent the infection from advancing to TB, may be warranted.[17] It should be noted that even if the drug treatment successfully eliminates the Mtb infection and prevents the development of active disease, the patient will continue to test positive on later tuberculosis skin testing because his or her immune system will "remember" the Mtb protein and react to the skin test.

Interpreting skin tests for Mtb infection can be complicated by the fact that, over a period of years, some infected people initially test negative because their immunologic "memory" has faded. The test, however, "reminds" the person's immune system to react, which will cause positive results on a subsequent test. This test might then be incorrectly interpreted as evidence of a new infection in the time between the two tests. To avoid this problem, a "two-step" test procedure is recommended by CDC for the first skin test administered to a person being enrolled in a tuberculosis skin testing program. If the first test is negative, a second skin test is given a week later. If the second test is also negative, the person is considered to be free of Mtb infection and can then be enrolled in the periodic screening program (they need only receive a single skin test at each subsequent periodic screening).[4]

A diagnosis of active TB should be considered for any patient with persistent cough or other symptoms compatible with TB. This is further complicated for HIV-infected individuals, since several other respiratory diseases present the same symptoms as TB. Because active TB is generally not diagnosed until symptoms occur, there is a time period before diagnosis that the patient is infectious but has not been isolated. For this reason, early diagnosis of TB is critical for minimizing transmission. Upon diagnosis, the appropriate drug therapy should be promptly initiated and the patient isolated until the drug therapy has killed enough bacteria to leave the patient non-infectious. A patient is generally considered non-infectious after receiving effective drug therapy, symptoms are noticeably reduced, and the sputum samples are negative for Mtb on three consecutive days.[5]

Among persons with HIV infection, the difficulty in making a diagnosis may be complicated by an impaired immune response to a tuberculin skin test, resulting in a negative skin test reaction (anergy).[18,19] Even though false-negative results may occur, CDC recommends that persons with HIV infection, with or without AIDS, should receive a Mantoux skin test, since a positive reaction ($>$5-mm induration) is clinically meaningful.[6] If a positive reaction is obtained, a chest radiograph should be obtained and the person should be placed on preventative therapy. Furthermore, persons with clinical AIDS or other HIV-related disease should receive a chest radiograph as part of the initial screening, regardless of their PPD status. CDC has recommended additional guidelines regarding the evaluation and management of persons who may have TB infection and HIV-induced anergy to delayed-type hypersensitivity (DTH) skin test antigens, including PPD-tuberculin.[18] Based on these recommendations, persons with HIV infection should be evaluated for DTH anergy in conjunction with PPD testing. Anergy is determined by the administration of two delayed-type hypersensitivity (DTH) antigens by the Mantoux intradermal technique.[18]

Another factor which makes diagnosis of TB difficult in persons with HIV infection is low sensitivity of sputum smears for detecting Mtb; this is most likely due to the lower frequency of cavitary pulmonary disease observed among HIV-infected persons.[20] In addition, the diagnosis may be overlooked because of an atypical clinical or radiographic presentation, and the simultaneous occurrence of other pulmonary infections.[21]

Discussion of Administrative Controls

Residents will enter the program through referrals by homeless shelters, drug treatment centers, health clinics, and correctional facilities. Once initial contact has been made with the client, medical histories regarding Mtb exposure, infection, disease, and treatment, will be collected prior to acceptance into the program. According to the Alaskan AIDS Assistance Association's written policy regarding the acceptance of residents into the facility, residents will not be admitted without proof of prior TB history which will include chest X-ray results. Since long-term residents will be referred from other facilities, this information should be readily available. All short-term residents will reportedly be evaluated for Mtb infection and TB by the Alaskan Native Medical Center before referral to the center.

The facility does not have an established written TB control program for the early identification of employees with active TB, as required by OSHA. However, PPD skin testing will reportedly be provided to on-site employees at the beginning of employment and every six months thereafter. Any resident suspected of having active TB will be immediately transported to the appropriate medical facility for diagnoses and treatment of TB. If this is not immediately possible, the resident will be placed in a room within the facility which will ensure that interaction with the other residents and staff is limited until they can be taken to an appropriate medical facility. If TB is diagnosed, the client will not be allowed to return to the facility until they are no longer infectious, since the facility does not have on-site personnel to deal with a client who has active TB, and since other residents will be highly susceptible to Mtb infection.

ENGINEERING CONTROLS

Evaluation Criteria and Guidelines

Ventilation

Because infection requires the inhalation of aerosolized Mtb, the probability that a person will become infected depends upon the concentration of infectious droplet nuclei in the air. Environmental factors which enhance transmission include: the sharing of a relatively small, enclosed space with an infectious person; inadequate ventilation; and recirculation of air containing infectious droplet nuclei.[5]

There are two types of ventilation used for control of airborne transmission of Mtb; general dilution ventilation and local exhaust ventilation. General dilution ventilation provides a general exchange of contaminated indoor air with uncontaminated air thereby diluting the airborne concentration of infectious agents and reducing potential exposures to workers and other susceptible persons (i.e. patients and visitors). Local exhaust ventilation removes contaminated air from the immediate area surrounding the infectious person without exposing other persons nearby. Each of these types of ventilation is explained more fully below.

General Dilution Ventilation

General ventilation reduces the concentration of contaminants through dilution and removal of contaminated room air. There are two basic designs for general ventilation systems. The first, a "single pass" system, theoretically exhausts all room air to the outside. The second design recirculates most of the air, with a small portion being exhausted and replaced with "clean" outside air. The primary advantage of the single-pass design is that contaminated air is exhausted directly to the outside and not recirculated within the building; the principal disadvantage is the greater cost of heating or cooling the necessary additional outside air. Heat recovery systems can be used with recirculating systems.

Ventilation rates are frequently expressed in terms of air changes per hour (ACH). An ACH is defined as the theoretical ratio of the ventilation rate (volume of air entering the room per hour) to the room volume, assuming perfect mixing. This terminology can be misleading because the total volume of room air may not actually be "changed" the number of times per hour due to imperfect air flow mixing patterns in the room.

The American Society of Heating, Refrigerating, and Air-Conditioning Engineers (ASHRAE) and the American Institute of Architects (AIA) have recommended at least six ACH for health care facility isolation and treatment rooms based on comfort and odor control.[22,23] However, there are no laboratory or clinical data that can validate any significant control of worker exposure to droplet nuclei containing Mtb bacteria at these recommended air flow rates. Hospital-ventilation studies published in the 1960's provide evidence to indicate that six ACH in hospital rooms do not effectively control airborne bacteria.[24,25,26]

It is important to recognize that the available studies do not permit quantitative estimation of the risk of infection at any given level of general ventilation. Similarly, the available studies do not permit quantitative estimation of decreases in risk that would result from specific increases in general ventilation levels from six ACH to substantially higher values. However, the data indicate the need to have general ventilation rates at the highest possible levels to reduce exposure to droplet nuclei. Therefore, it is recommended that facilities be designed to achieve the best general ventilation air flows (striving for substantially greater than six ACH) in those areas where confirmed or potential tuberculosis patients are present (e.g., isolation and treatment rooms).

In addition to supplying the specified airflow, ventilation systems should also provide satisfactory airflow patterns both from area to area and within each room. Airflow should be from "clean" to "less clean" areas, such as from hallways to treatment rooms. This can be accomplished by creating a negative pressure in the area into which flow is desired relative to adjacent areas. Negative pressure is attained by exhausting more air from the area than is being supplied, preferably directly exhausting the air to the outside. Rooms where Mtb is likely to be present, such as isolation and examination rooms, should be under negative pressure with respect to adjacent corridors.[23] Pressure differentials can only be maintained in closed rooms; therefore, it is important that doors are closed tightly and are kept closed as much as possible. Exhaust locations should not be near areas that may be populated (e.g., sidewalks or windows that may be opened). Exhaust points should also be away from air intakes, so that exhaust air is not circulated back into the facility.

Within a room or small area, a ventilation system should be designed to: 1) move air to all areas of the room (prevent stagnation of the air); 2) prevent short circuiting of the supply to the exhaust (i.e., passage of air directly from the supply site to the exhaust point without mixing of room air); and 3) direct the clean air past the worker without recirculation within the room. These conditions are not always achievable but should be attempted to the fullest extent feasible. One way to accomplish this is to supply low velocity air at one end of a room and exhaust it from the opposite end. Another method is to supply low velocity air near the ceiling and exhaust it near the floor. However, air flow patterns are also affected by air temperature, the precise location of supply and exhaust vents, vent or diffuser design, the location of furniture, movement of workers, and the physical configuration of the space. Each room or space must be evaluated individually.

The use of high efficiency particulate air (HEPA) filtration has been proposed as a measure to control Mtb transmission. HEPA filtration should be effective at reducing air concentrations of Mtb. Research has shown it to be effective at reducing air concentrations of *Aspergillus* spores which are of a similar size range to aerosolized Mtb particles.[27,28,29] HEPA filters can be used to clean air before it is recirculated into other parts of a facility or back into the same area, or exhausted to the outside. HEPA filtration systems require proper installation, periodic leak testing, and meticulous maintenance.

Ideally, ventilation systems used in areas where Mtb may be present should supply non-contaminated air (a portion should be outside air), discharge exhaust air to the outside, and should not recirculate air back into the facility. Where Mtb may be present, an area of the facility should be selected where the ventilation can be optimized to provide the desired ventilation parameters. Where this is not possible, less desirable alternative approaches may be used. In cases where a room has no ventilation, a HEPA-filtered recirculating system for that room might be considered. In no case should a room or area without mechanical exhaust ventilation be used for patients with TB.

Local Exhaust Ventilation

Local exhaust ventilation captures the infectious agent in the immediate field of an infectious patient (i.e., scavenging booths or tents) without exposing other persons in the area. It is the preferred type of ventilation because the Mtb organisms are removed before they can disperse throughout the work area. Local exhaust ventilation is used most effectively in a fixed location. The hood portion of a local exhaust system may be of exterior design, where the infection source is near but outside the hood, or enclosing, where the infectious source is within the hood. Enclosures (booths) are available for aerosol-generating activities, such as sputum collection and aerosol therapy. These devices may be exhausted directly to the outside, or they can exhaust through a HEPA filter back into the room.

Discussion of Engineering Controls

Prior to the NIOSH site visit, the blueprints of the facility were reviewed to select a room which could be remodeled for limited access. This room would be used to separate a suspected infectious individual from the other residents of the facility in limited cases when immediate transport to an appropriate health care facility is not possible. Based on a review of the plans and a walk-through inspection of the facility, the basement apartment in Unit B was chosen due to its remote location and the ability to optimize ventilation rates (see Figure 1). Ventilation requirements for the room were evaluated.

As stated previously, a ventilation rate substantially greater than six ACH is recommended for areas where individuals with confirmed or suspected TB are present. In order to achieve the appropriate ventilation for the isolation room, the architect proposed a fixed-plate heat exchanger in the window well of this room which would potentially provide a ventilation rate of 210 cubic feet per minute (cfm) exhaust air flow. This type of heat exchanger alternates layers of plates, separated and sealed, which form the exhaust and supply airstream passages. It should be noted that these types of heat exchangers may result in 0-5% cross-leakage between the supply and exhaust airflows, depending on how well the unit is maintained.[30] The bathroom exhaust, located in Unit B, can provide an additional exhaust ventilation rate of 50 cfm if operated continuously. Based on the room volume (1710 ft^3), 9.1 ACH should be achieved. A portable, recirculating HEPA filtration unit can offer additional filtration to the room air. Since the building was still under renovation, no ventilation measurements were taken during the evaluation.

It should be noted that although substantially higher than six ACH should be achieved in this room, there may be opportunities for deficiencies to occur with this approach for providing ventilation (in contrast to the operational capacity of a central HVAC system). For example, the effectiveness of a portable, recirculating HEPA unit is highly dependent on its location within a room with respect to air flow patterns and location of the infectious source (each of which may vary with time). Additionally, adequate information on the capture efficiencies for these types of units is limited and may vary between different manufacturers. The location of the unit may also affect whether the room remains under negative pressure with respect to adjacent areas. Another potential problem which will need further evaluation is the potential for short-circuiting of the air supply by the heat-exchanger. Since the supply and exhaust airstreams are in close proximity to one another, there is the potential that a portion of the room will not receive adequate ventilation.

RESPIRATORY PROTECTION

Evaluation Criteria and Guidelines

In addition to engineering controls, NIOSH recommends that personal respiratory protection be used to reduce the risk of Mtb infection. NIOSH considers this to be necessary because of the lack of available data to fully assess the efficacy and reliability of the engineering controls discussed above. The Occupational Safety and Health Administration (OSHA) enforcement policy, which is based on recommendations made by CDC, requires the use of NIOSH-approved high-efficiency particulate air (HEPA) half-mask respirators (including disposables) as a minimum level of protection when employees enter isolation rooms, when performing medical procedures such as bronchoscopy and sputum induction, and while transporting patients.[16] NIOSH recommends that workers exposed to patients with infectious TB wear respirators that meet the performance criteria CDC has outlined.[31] Surgical masks do not offer appropriate protection from TB, since they do not provide adequate protection to the wearer due to poor face seal characteristics and potential leakage of small particles through the filter media.

A complete respirator program must be implemented that meets the requirements of the OSHA respiratory protection standard (29 Code of Federal Regulations 1910.134).[32] The minimum requirements for a respiratory protection program include a written standard operating procedure for the selection and use of respirators; training and instructions on respirator usage; the cleaning, repair, and housing of respirators; the continued surveillance of work area conditions for worker exposure and stress, and for the evaluation of the effectiveness of the respiratory program; and the medical evaluation of employees to determine that they are physically able to wear the respirator selected for use.

In addition to the use of respirators by health care providers, the wearing of respiratory protection by infectious persons may also reduce Mtb exposures; surgical masks may be appropriate for this purpose.

Discussion of Respiratory Protection Issues

Many of the health-care providers who will participate in this program have reportedly been wearing surgical masks while in the presence of an individual with suspected or confirmed Mtb-infection. A personal respiratory protection program meeting OSHA requirements had not been implemented for the health-care providers and volunteers.

CONCLUSIONS AND RECOMMENDATIONS

The use of appropriate administrative controls, engineering controls, and respiratory protection will reduce the potential for Mtb transmission in the residential facility. The most important factors in preventing the transmission of Mtb in the facility is the early identification of those individuals who are suspected of having active TB, followed by their immediate removal from the facility. If, for various reasons, a suspected infectious resident cannot be immediately transported to an appropriate medical facility, the resident should be placed in a room which offers limited access to the other residents ideally with a separate ventilation system. Although there are presently no guidelines pertaining to Mtb transmission in residential facilities for HIV-infected individuals, the following recommendations are offered to aid in the reduction of Mtb transmission in the facility.

ADMINISTRATIVE CONTROLS

1. Upon initial employment, staff and volunteers should receive a PPD skin test. Clients should also be tested if they have not already been evaluated for Mtb infection. CDC recommends that a two-step test procedure be used for the first skin test administered to a person being enrolled in a tuberculosis surveillance program. If the first test is negative, a second test should be given a week later. This will reduce the likelihood that a boosted reaction will, upon subsequent testing, be interpreted as a recent infection.[4] CDC recommends that health-care workers subsequently receive at least annual screening; employees who routinely perform procedures with a high risk of exposure to Mtb should be retested at least every six months.[5]

2. A written skin testing protocol for the staff, including volunteers, and the clients should be prepared. The results of annual, semi-annual, and contact investigation tuberculin skin tests should be maintained in a central file and should be periodically reviewed to evaluate the efficacy of the TB control program.

3. Even though false-negative results may occur, persons with HIV infection, with or without AIDS, should receive a TB skin test.[6] Many of the residents will remain with the program for more than a year; therefore, all tuberculin-negative clients should be retested at 6- to 12-month intervals. Additionally, CDC recommends that persons with HIV infection should be evaluated for DTH anergy in conjunction with PPD testing.[19]

4. Clients residing at the facility should be closely monitored in order to identify and isolate persons with symptoms suggestive of active TB. Suspected cases should be referred for medical evaluation and treatment as soon as possible. If active TB is diagnosed, contacts should be quickly identified and evaluated for evidence of infection.[2] In addition to the semi-annual testing, all employees who are exposed to a client with active TB should be retested unless a negative tuberculin skin test has been documented within the preceding three months. If the initial test is negative, the test should be repeated 12 weeks after exposure.[18]

5. Residents, employees and health care providers must be informed of the frequently uncharacteristic presentation of TB in this group so that the diagnosis is not overlooked.[6] Failure to diagnose and manage patients appropriately can result in infection of contacts, including other patients, visitors, volunteers, and health-care personnel.

VENTILATION REQUIREMENTS

1. The ventilation system in the basement of Unit B should be fully evaluated to ensure that the system is properly operating, and any deficiencies found should be corrected. Generated smoke or pressure monitors should be used to observe whether the room is under negative pressure. Generated smoke should also be used to visualize air flow patterns in the room, and to observe how these patterns are affected by varying room conditions (e.g., doors open/closed, exhaust fans on/off). If a portable HEPA unit is installed, it should be placed in a position which will provide the greatest amount of recirculation or filtration (avoid placing the unit in a corner or in a location with little air movement). Air flow rates should be evaluated to ensure that substantially greater than six ACH are achieved at all times in the room. Air exhausted from the room by the heat exchanger should be ducted to the roof to avoid entraining contaminants into the building.

2. All exhaust and recirculating filtration systems in the basement of Unit B should run continuously when a resident, suspected of having TB, must use the room. The bathroom exhaust fan should be disconnected from the light switch and placed on an independent control switch.

3. The facility should develop and implement a written preventive maintenance program for the ventilation components of the facility including filter change criteria for the heat exchanger and the portable HEPA filters in the isolation room. These criteria should include change frequency, monitoring for filter leakage, necessary safeguards to be followed by maintenance personnel (gloves, respirators), and proper disposal methods (i.e., bag-in, bag-out

procedures). Filters should be treated as potentially contaminated with infectious microorganisms.

4. No high-risk procedures such as sputum inductions and/or administration of pentamidine should be performed at the facility. These activities should only be performed at a properly equipped medical facility where the appropriate controls (local exhaust systems such as HEPA-filtered booths or scavenging tents) are in place to prevent the spread of infectious aerosols into the general room air circulation.[21]

RESPIRATORY PROTECTION

1. Personal respiratory protection should be worn by anyone entering the basement apartment of Unit B when a resident, suspected of having active TB, is present. HIV-infected individuals should be advised of the risk posed to them by being exposed to Mtb. Respiratory protection must also be worn during the transportation of a suspected infectious individual to another facility.

2. A respiratory protection program which meets the OSHA requirements (29 CFR 1910.134) should be in place at the facility.[32] The written program should include those individuals who will enter the basement of Unit B when a resident, suspected of having active TB, is waiting to be transported to a medical facility, and those who will transport suspected infectious residents from the facility. The program should be periodically reevaluated for its effectiveness.

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FIGURE 1
Facility Lay-Out
Alaskan AIDS Assistance Association
Anchorage, Alaska
HETA 93-0771